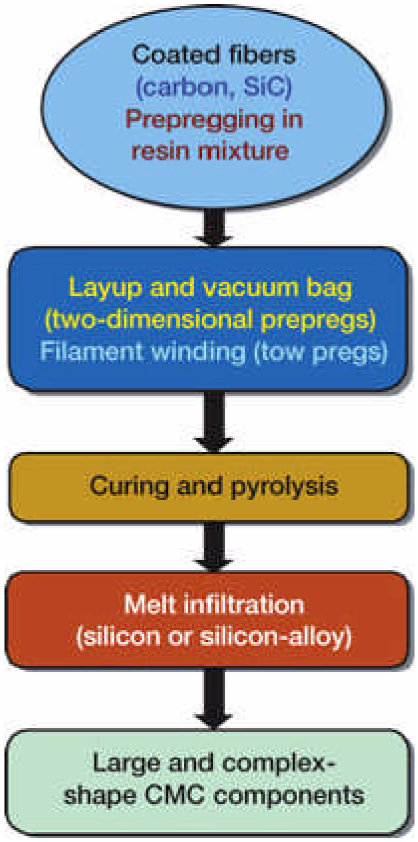
Prepreg and Melt Infiltration Technology Developed for Affordable, Robust Manufacturing of Ceramic Matrix Composites

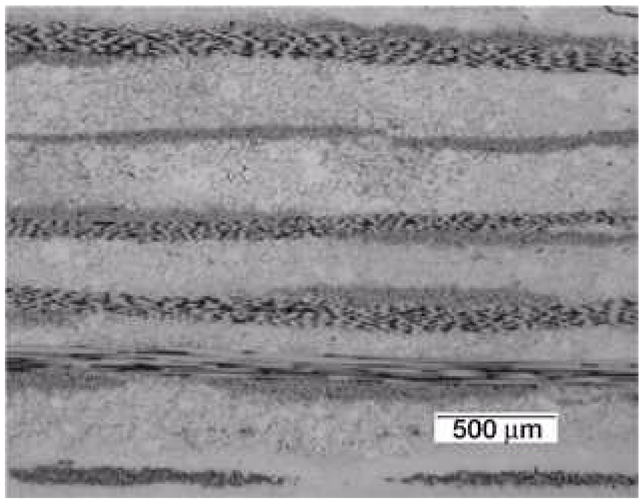
Affordable fiber-reinforced ceramic matrix composites with multifunctional properties are critically needed for high-temperature aerospace and space transportation applications. These materials have various applications in advanced high-efficiency and high-performance engines, airframe and propulsion components for next-generation launch vehicles, and components for land-based systems. A number of these applications require materials with specific functional characteristics: for example, thick component, hybrid layups for environmental durability and stress management, and self-healing and smart composite matrices. At present, with limited success and very high cost, traditional composite fabrication technologies have been utilized to manufacture some large, complex-shape components of these materials. However, many challenges still remain in developing affordable, robust, and flexible manufacturing technologies for large, complex-shape components with multifunctional properties. The prepreg and melt infiltration (PREMI) technology provides an affordable and robust manufacturing route for low-cost, large-scale production of multifunctional ceramic composite components.



Various steps in the prepreg and melt infiltration (PREMI) process.

Flexible prepregs for the fabrication of large, complex shapes.

The PREMI technology for ceramic matrix composites fabrication, which was developed at the NASA Glenn Research Center, has four steps. These are shown in the preceding flow chart. In the first step, coated carbon and silicon carbide fibers are prepregged in a proprietary resin and particulate mixture and are B-staged to provide a tacky finish. Fiber tows can also be tow-pregged for filament winding. Flexible prepregs, shown in the preceding photograph, can be used to fabricate large, complex shapes. In the second step, the prepreg cloths are laid up and vacuum bagged for curing. The third step is curing and pyrolysis, which yields an interconnected network of porosity in the matrix. In the final step of the process, the preform is infiltrated with molten silicon or refractory metal-silicon alloys in a furnace. This converts the carbon to silicon carbide. This process is also suitable for making composites with hybrid layups and two- or three-dimensional architectures by filament winding or other fiber placement techniques. This processing approach leads to dense composites, where matrix microstructure and composition can be tailored for optimum properties. It has a much lower processing cost (<50 percent) in comparison to other approaches to fabricating ceramic matrix composites. Thermomechanical and thermochemical characterization of these composites under the hostile environments that will be encountered in various aerospace applications is underway.



Dense SiC(Sylramic)/SiC ceramic composite fabricated by the PREMI process.

QSS contact: Dr. Mrityunjay (Jay) Singh, 216-433-8883;
Mrityunjay.Singh@grc.nasa.gov
Authors: Dr. Mrityunjay Singh and Jeannie F. Petko
Headquarters Program Office: OAT
Programs/Projects: NGLT